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Residential demand response program modelling to compliment grid composition and changes in energy efficiency

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Key messages

- Grid composition plays a significant role in residential DR program effectiveness
- Amount of VRE resources on grid impacts how DR potential is utilized
- DR program effectiveness may increase with improved building stock efficiency

Importance: Demand response programs are an underutilized balancing technology

Demand response (DR) is an important tool in the modern grid. Historically, electricity supply responds to demand, since conventional electricity generation sources have been fuel driven and flexible; however, in electricity systems with high levels of variable renewable energy (VRE) generation, this control of the electricity supply is not possible, since it is subject to the availability of the demand side resource. DR refers to when electricity customers change their consumption patterns in response to an external stimulus (McPherson & Stoll, 2020). DR programs have been shown to aid power system operations by reducing peak load, postponing transmission upgrades, and facilitating VRE integration (Bergaentzlé et al., 2014; Bitaraf & Rahman, 2018; Jordehi, 2019; Strbac, 2008). In Canada, DR is underutilized, particularly in the residential building sector. Of the three DR programs offered in Canada, they are only feasibly accessible to large consumers, despite residential buildings representing almost a third of national electricity demand (Canada Energy Regulator, 2021).

Opportunities and barriers: Despite significant value to the grid, consumer savings are marginal

DR programs bring high-value to grids with high VRE penetration; whether composing the majority of generation capacity or in conjunction with high-emitting generators, these grids are able to dispatch building DR programs much more effectively than low-VRE grids. These grids also exhibit significant reductions in greenhouse gas (GHG) emissions due to higher utilization of available VRE generation, making DR programs beneficial for meeting climate change mitigation goals. In these grids, increasing the efficiency of the building stock leads to DR being more effective at decreasing both operational costs and GHG emissions. At its most impactful, DR programs has a value to the grid of up to \$68/MWh of demand shifted, representing a total operational cost reduction of just over 5%.

While the value of DR can be high, the value to the individual consumer is low, potentially presenting a significant barrier to DR program participation. Since such a high percentage of residential participants is needed to be impactful, the value of DR pro-grams to the grid are only marginally passed onto consumers. The highest cost savings, even on grids that utilized building DR very effectively, are under 3% of their typical electricity bill.

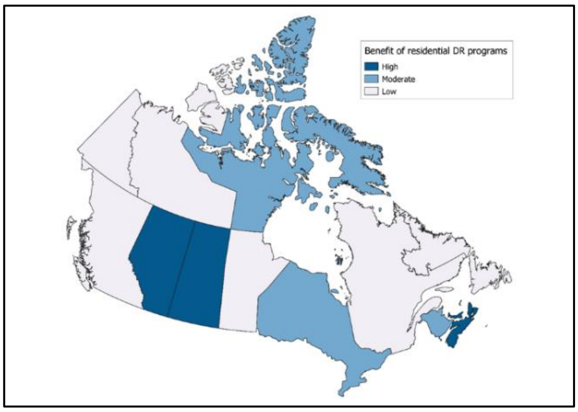

Figure 1: Benefits of residential DR programs based on projected grid composition.

Next steps: Where in Canada are demand response programs viable?

Alberta, Saskatchewan, Nova Scotia, and Prince Edward Island will likely see the greatest benefits from DR programs (Figure 1). These grids are categorized as either flexible and carbon-intensive grids, or inflexible and low-emitting. The inflexible and low emitting grids (i.e., Alberta and Saskatchewan) would specifically benefit from higher DR program enrollment due to the amount of VRE curtailment still present on the grid. Decision makers and system operators may benefit from factoring these local characteristics into their decision-making process when designing details of residential DR programs.

References

Bergaentzlé, C., Clastres, C., & Khalfallah, H. (2014). Demand-side management and European environmental and energy goals: An optimal complementary approach. *Energy Policy*, *67*, 858–869. https://doi.org/10.1016/j.enpol.2013.12.008

Bitaraf, H., & Rahman, S. (2018). Reducing Curtailed Wind Energy Through Energy Storage and Demand Response. *IEEE Transactions on Sustainable Energy*, *9*(1), 228–236. https://doi.org/10.1109/TSTE.2017.2724546

Canada Energy Regulator. (2021, January 29). *Market Snapshot: Canada's electricity demand is increasing steadily*. Canada Energy Regulator. https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2020/market-snapshot-canadas-electricity-demand.html

Jordehi, A. R. (2019). Optimisation of demand response in electric power systems, a review. *Renewable and Sustainable Energy Reviews*, *103*, 308–319. https://doi.org/10.1016/j.rser.2018.12.054

Strbac, G. (2008). Demand side management: Benefits and challenges. *Energy Policy*, *36*(12), 4419–4426. https://doi.org/10.1016/j.enpol.2008.09.030